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## NEW OR INTERESTING TROPICAL AMERICAN DOTHIDEALES—II.

*by*

CARLOS E. CHARDON

## LIFE HISTORY OF LIGNIERA VASCULARUM (Matz) Cook

*by*

MELVILLE T. COOK

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# NEW OR INTERESTING TROPICAL AMERICAN DOTHIDEALES—II *

CARLOS E. CHARDON

(WITH PLATES I AND II)

Since the publication by the writer (1) of the first paper on the Dothideales, a renewed interest in this group has been aroused due to the fact that Doctor H. Sydow of Berlin has expressed his intention of revising his well known monograph on the group (5) which is indeed in great need of revision, especially in regard to the Tropical American species.

The present paper, in the writers opinion, is a further evidence that such a revision is imperative. The critical study of the grass forms occurring in Porto Rico and Santo Domingo has proved to be suprisingly interesting and a number of forms which had been determined and reported in the work of Seaver and Chardon (3), after comparing with authentic type material or with forms already known from the continent, has turned out to be either species new to science, or else they have been referred to continental species. On the contrary, species like *Pyllachora Eriocholae* Speg. which had been reported as occurring in Porto Rico and Santo Domingo, have been eliminated from the flora of both islands.

If such a chaotic situation has prevailed in our knowledge of the Dothideales of Porto Rico, an island which has been so thoroughly explored by a dozen mycologists in the past fifteen years and the collections of which have been critically studied by the best American specialists in the different groups, the rest of tropical America no doubt offers, as it was previously stated "a vast field of investigation for systematic mycologists."

An additional paper by the writer (2), although not part of this series, has also appeared in which a number of new Phyllachorae have been described from Colombia. These were collected by the writer in the region of the Central Andes and along the banks of the Magdalena River in 1926.

The species herein described as new or interesting have been collected by various mycologists and by the writer in Porto Rico and deposited in part in the writer's personal herbarium; by Doctor

* For the first contribution see Mycologia 19: 295–301. 1927.

F. D. Kern and Mr. R. A. Toro in Santo Domingo in 1926; by Mr. R. A. Toro, who has lately been stationed in Medellín, Colombia; and material from various collectors of the U. S. Department of Agriculture from South America, which has been kindly communicated for study by Mr. John A. Stevenson, in charge of the mycological collection in the Bureau of Plant Industry, Washington, D. C. To all of these collectors the writer wishes to express his indebtedness.

Seaver (**4**) in a recent publication has also given some attention of species of *Phyllachora* from Tropical America. His use of the name *Phyllachora* "in a broad sense" may seem somewhat objectionable to those of us who have accepted Theissen and Sydow's classification of the group.

An expression of appreciation is also due to Doctor H. Sydow, of Berlin, for kindly supplying type material and to Don Mario Brau, of the Museum of the Department of Agriculture of Porto Rico for the colored plates accompanying the paper.

DOTHIDEACEAE.

BAGNISIOPSIS TIJUCENSIS Theiss et Syd., Annal. Mycol. **13**: 291. 1915.

Two specimens from Colombia collected by R. A. Toro are referred to this species, which was only previously known from near Río de Janeiro, Brazil. The stromata showed the characteristic dothideoid and erumpent character of *Bagnisiopsis*. Spores 1–celled, hyaline, uniseriate in the ascus, elliptical, 13–14 × 5–6 u, which are slightly smaller than the description given by Theissen and Sydow.

On *Tibouchina longifolia* (Vahl.) Baill.

COLOMBIA: R. A. Toro No. *264*, Guarnes, Dept. of Antioquia, Nov. 3, 1927; R. A. Toro, No. *303*, near Medellin, Dept. of Antioquia, Jan. 20, 1928.

**Achorella Toroana** Chardon spec. nov.

Spots approximately circular, or irregular through coalescence, very conspicuously epiphyllous with the borders limited by a violet tinge, sometimes hypophyllous; stromata dothideaceous, warty, erumpent, black, mostly multiloculate, the locules globose or slightly irregular through lateral pressure, 350–400 × 250–300 u, the walls of the stroma when placed in water dissolving into a very conspicuous greenish blue substance; asci cylindrical, 8–spored, with the spores early evanescent from the asci, 158–172 × 11–15 u; spores 2–celled, distinctly brown, provided with a distinct cell wall, uniseriate in the ascus, 23–26 × 9–11; paraphyses present.

This is a very interesting new form: the stroma is evidently

dothideaceous, resembling a *Bagnisiopsis* or a *Dothidina,* but the 2-celled, brown character of the spores makes it fall in the genus *Achorella.* The fungus is unique in tha the walls of the stroma when placed in water for examination under the miscroscope, secrete an opaque, greenish blue substance.

The species is dedicated to its collector, Mr. Rafael A. Toro, Porto Rican mycologist, now in Medellin, Colombia.

On *Cavendishia* Spec.

COLOMBIA: R. A. Toro, No. *260,* Guarnes, Dept. of Antioquia, Nov. 3, 1927 (*type*).

**Dothidina sphaerospora** Chardon spec. nov.

Spots hypophyllous, not exceeding the stromata; stromata dothideaceous, warty, black, coalescing and aranged in conspicuous, circular clusters 1–3 mm. across; locules globose or slighly irregular through lateral pressure, 300–400 × 250–300 u, asci cylindrical, 8-spored, uniseriate, with the sporiferous part 56–65 × 7 u; spores 1-celled, globose, 8 × 7 u, at first hyaline, provided with a distinct cell wall, later becoming light brown in color, uniseriate; paraphyses profuse.

This fungus is evidently not *Dothidina peribebuyensis* (Speg.) Chardon (Mycologia **13**: 289. 1921) which has spores 14–18 × 6–7 u and reported on various Melastomaceae from South America and Porto Rico, while they are globose 8–7 u, in the Colombian specimen. It is a true dothideaceous form, with erumpent stromata.

On *Clidemia impetiolaris* (Naud.) Cogn.

COLOMBIA: R. A. Toro No. *314,* vicinity of Medellin, Dept. of Antioquia, Jan. 20, 1928 (*type*).

PHYLLACHORACEAE.

**Trabutia Mangiferae** Chardon spec. nov.

Spots irregular or roughly circular, amphigenuos, brownish brick colored, 12–15 mm. across; stromata hypophyllous black, shiny, irregular, angular, 3–5 mm. across; stroma multiloculate, distinctly situated between the cuticle and the epidermis; locules flat ellipsoidal or angular through lateral pressure, fully immersed in the clack stroma, 240–325 × 120–200 u, asci cylindrical clavate, 8-spored, with the spores biseriate in the main body of the ascus, 62–75 × 15–17 u, spores 1-celled, hyaline, ellipsoidal, 10–12 × 5–6 u; paraphyses present. (Plate II, Fig. 5.)

There is only one dothideaceous fungus reported on this host. *Zimmermanniella trispora* P. Henn. from Buitenzorg, Java. (*Theiss.* & Sydow p. 290). This rare genus is a 3-spored *Bagnisiopsis,* while

the species under study is very evidently a new species of *Trabutia,* since the stroma is quite distinctly between the cuticle and the epidermis.

On *Mangifera indica* L.

BRAZIL: U. S. Dept. Agr. No. *61130* (coll. by J. R. Weir), Santa Laura, Madeira River, Amazonas, Aug. 31, 1923 (*type*).

**Catacauma costaricense** Chardon nom. nov.

*Phyllachora Pittieri* Speg. Bol. Acad. Nac. Ci. Cordoba **23**: 569. 1919. Not *Ph. Pittieri* Theiss & Syd. Ann. Mycol. **13**: 544. 1915.

It may be interesting to state briefly the nomenclatorial entanglement that has resulted in the adoption of a new name for this species. *Phyllachora Pittieri* was described by Spegazzini in 1919 from material collected by A. Tonduz in Costa Rica in 1897. The specific name is not valid because there is another *Ph. Pittieri* named by Theissen and Sydow in 1915. (Ann. Mycol. **13**: 544).

Prof. Sydow later reported (Ann. Mycol. **24**: 398) two of his collections from Costa Rica as *Pyllachora Pittieri* Speg. These two collections have been examined by the writer, and microscopic sections of the leaves have shown the position of the stroma to be between the epidermis and the mesopyll, thus making this species to fall under the genus *Catacauma.* With the specific name *Pittieri* not valid, and the genus changed from *Phyllachora* to *Catacauma,* the fungus has to be entirely renamed as *Catacauma costaricense* Chardon nom. nov.

In both of Sydow's specimens the spores (11–13 × 6–7 u) are smaller than in Spegazzini's description. This author reports them as 15–16 × 7–9 u.

A third collection by Standley, from Honduras, communicated by Mr. John A. Stevenson, has also been referred here. The spores are also 11–13 × 6–7 but mostly biseriate in the ascus and become somewhat opaque at maturity.

On *Xylosma velutina* Tr. & Planch.

COSTA RICA: H. Sydow No. *92,* La Caja, near San José, Dec. 22, 1924.

On *Xylosma oligendri* Donn. Sm.

COSTA RICA: H. Sydow No. *134,* Cerro de San Isidro, near San Ramón, Feb. 7, 1925.

On *Xylosma* sp.

HONDURAS: U. S. Dept. Agr. No. *55989* (coll. by P. C. Standley), vicinity of Siguatepeque, Feb. 14–27, 1928.

**Catacauma Ingae** Chardon spec. nov.

Spots approximately circular, yellowish, very small, inconspicuous, 1–1.5 mm. in diameter; stromata epiphyllous, scattered, small, very inconspicuous, 0.5–0.8 mm. across, circular, unilocular, situated between the epidermis and the mesophyll forming a clypeus over the locule, 45–60 u thick, with a portion of compact stromatic tissue in the hypophyll just below the locule but not touching it; locule flat, 300–400 × 80–100 u, asci cylindrical-clavate, 8-spored with the spores inordinate in the ascus, 75–90 × 13–15 u; spores long navicular, hyaline, continuous, 24–26 × 3.5–4 u, provided with several oil drops: paraphyses present.

This species had evidently escaped the attention of the mycologists that have visited Porto Rico due to its minute, inconspicuous stromata. *Ophiodothella Ingae* (P. Henn.) Th. & Syd. reported on *Inga* spec. from São Paulo, Brazil, is evidently different from this species in possessing filiform spores in a parallel arrangement in the ascus.

On *Inga vera* L.

Porto Rico: C. E. Chardon No. ——* Maricao Insular Forest Reserve, June 9–10, 1928 (*type*).

**Catacauma semi-lunata** Chardon spec. nov.

Spots not exceeding the stromata but identified with them; stromata black, shiny, occasioning a tar-spot, very conspicuous, epiphyllous, either oval or slightly irregular at first, 3–5 mm. in diameter but often becoming confluent into large irregular, tar-like masses 6–10 mm. across, multilocular in cross section, with 3–5 or even more locules, the stroma located between the epidermis and the mesophyll, the stromatic tissue much more compact and solid black in color above the locules and on their sides; locules globose or ellipsoidal, sometimes angular through lateral pressure, 150–250 × 100–150 u; asci cylindrical clavate, 8-spored, with the spores arranged biseriately in the ascus; spores hyaline, 1-celled, lunulate, 14–18 × 4–5 u; paraphyses present. (Plate I, Fig. 1).

The shape of the spores of this species, is very characteristic and unique for the group; they are crescent shaped which is very distinctive. This curious spore shape may perhaps serve to justify the erection of a new genus in the Scirrhiineae of the Phyllochoraceae, right next to *Catacauma* and *Catacaumella*, but for the present, the species is included as a *Catacauma* which includes all the forms of the Scirrhiineae having 1-celled, hyaline spores with paraphyses present.

On *Eugenia* sp.

Porto Rico: C. E. Chardon No. ——* Maricao Insular Forest Reserve, June 9–10, 1928 (*type*).

* The types of this and the following species were destroyed during the hurricane of September 13, 1928.

**Catacauma Weirii** Chardon spec. nov.

Spots approximately circular or irregular, conspicuous, pale yellow contrasting with the green tissue of the leaf, epiphyllous but also faintly visible in the hypophyll, 12–20 millimeters across; stromata pale black a, epiphyllous, not shiny, at first approximately circular or slightly angular, 2–3 mm. across, very distinctly between the epidermis and the mesophyll, later coalescing into large, laberynthiform stromata of various shapes, 15 to 20 mm., across; locules many in the stromata, sub-globose, very often flattened, or else angular thru lateral pressure, with most of the black stromatic tissue above or on their sides, very little or none below, 200–400 × 120–160 u; asci cylindrical-clavate, 8–spored, with the spores obliquely uniseriate in the ascus; spores hyaline, 1–celled, smooth, long elliptical with the ends obtuse, 12–13 × 6 u; paraphyses present. (Plate II, Fig. 3).

*Ph. tenuis* (B. & C.) Sacc. reported from Nicaragua on *Bauhinia* (Theissén & Sydow p. 489) has spores with the same dimensions as this species but being a *Phyllachora* is quite different from *Catacauma* in the position of the stroma within the leaf tissues. The laberynthiform stromata of this form, somewhat suggesting that of *Trabutia conspicua* Chardon (see Mycologia **19**, pl. 27, fig. 4) is very characteristic. Named in honor of its collector, the well known American mycological explorer, Dr. James R. Weir.

On *Bauhinia* sp.

Bolivia: U. S. Dept. Agr. No. *61126*, (coll. by J. R. Weir) Riberalta, Rio Beni, Sept. 28, 1923 (*type*).

**Robledia** Chardon gen. nov. (Phyllachoracearum).

Stromata between the epidermis and the mesophyll; asci cylindrical clavate; spores brown, 2–celled, the upper cell developed, the lower one papillate; paraphyses present. Type species, *Robledia tetraspora.*

In honor of Dr. Emilio Robledo, Colombian physician and botanist, resident in Medellin.

The erection of this new genus in the Scirrhiineae of the Phyllachoraceae is necessary in order to include those forms like the one described below with brown, 2–unlike celled spores (see Theissen and Sydow's keys in Ann. Mycol. **13**: 177). In the genus *Phaedothiopsis* Theiss. & Syd. the spores are brown 2–celled, with the cells alike, while in the new genus *Robledia*, the spores are also brown 2–celled, but the cells are unlike.

**Robledia tetraspora** Chardon spec. nov.

Spots not exceeding the stromata; stromata epiphyllous, black, not shiny, warty, globose to subglobose, 1–2 mm. across, situated

between the epidermis and the mesophyll; locules many in the stroma, elliptical or angular through lateral pressure, 125–180 × 80–120 u, with most of the black stromatic tissue above, with some on the sides and none below; asci cylindrical or cylindrical-clavate, 4-spored, 45–62 × 12–18 u, with the spores uniseriate or biseriate; spores 2-celled, yellowish brown, with the cells unlike, the upper cell long elliptical, 14–20 × 6–7 u, provided with a distinct cell wall, 1 u thick, the lower cell papillate, 2–3 u across; paraphyses present. (Plate I, Fig. 2).

This is a distinct species characterized by the 4-spored asci.

On *Eupatorium tacotanum* Klett.

COLOMBIA: R. A. Toro No. *312*, La Primavera, Dept. of Antioquia, Dec. 25, 1927 (*type*).

**Phyllachora Ortonii** Chardon spec. nov.

Stromata amphigenous, black, not shiny, 0.8–1.0 mm. long × 0.3–0.6 mm. wide, but coalescing to form a long linear row of stromata 4.0 to 8.0 mm. or even more in length, parallel to the main axis of the leaf; fructification simple, with a large globose or elliptical locule, 180–230 × 80–100 u, completely immersed in the mesophyll of the leaf, and surrounded on all sides by the black stroma; asci cylindrical-clavate, 8-spored, with the spores biseriate in the main body of the ascus, 80–92 × 13–18 u; spores hyaline, 1-celled, elliptical with somewhat acute ends, 13–15 × 5–6 u; paraphyses present.

This specimen appears determined in the herbarium as *Phyllachora Andropogonis* Schw., a species which according to Dr. C. R. Orton does not occur in Porto Rico; Dr. Orton is evidently correct since the spore dimensions given for *Ph. Andropogonis* are 16–20 × 6–8 u. In *Ph. infuscans* Winter (Theiss & Sydow, p. 456) reported on *Paspalum* sp. from Brazil, the spores are even larger, 22–27 × 9–11 u. In the opinion of the writer the erection of a new species is amply justified here, which is dedicated to Dr. C. R. Orton, who has given much study to the American grass forms of *Phyllachora*.

On *Paspalum millegrana* Schrad.

PORTO RICO: F. L. Stevens No. *6763*, Naguabo; no month specified, 1913 (*type*).

**Phyllachora brevifolia** Chardon spec. nov.

Stromata amphigenous, black, not shiny, 0.8 to 1.0 mm. long × 0.5 to 0.8 mm. wide, the longer dimension following the main axis of the leaf, mostly isolated, seldom coalescing; fructification simple, or very rarely 2-loculate, with the locule covered above and below with black stromatic tissue, locule flat with the lower surface straight, the upper distinctly convex, 180–250 × 45–60 u; asci cylindrical-clavate, 8-spored, with the spores mostly uniseriate or sometimes

partially biseriate, 54–62 × 9–11 u; spores hyaline 1-celled, distinctly lemon shaped with acute ends, 9–11 × 4–5 u; paraphyses present.

This species had been reported by Seaver and Chardon (p. 51), based on determination made by C. R. Orton, as *Phyllachora assimilis* Theiss & Sydow. An examination of a fragment of the type of this species (Butler No. *1250*) which was kindly supplied by Dr. H. Sydow has shown that the Porto Rican material is different from it. In *P. assimilis,* the stromata are always multiloculate, while in our form they are uniloculate or very rarely biloculate. Furthermore, in *Ph. assimilis* the spores are not lemon-shaped with acute ends, but ellipsoidal with blunt ends; the spore measurements are also different. These differences have determined the writer in erecting a new species.

On *Schizachyrium brevifolium* (Sw.) Ness. (*Andropogon brevifolius* Sw.).

Porto Rico: F. L. Stevens No. *5751* (Cornell University No. *11099*), Río Piedras, Nov. 3, 1913 (*type*); B. López No. *7899,* Experiment Station Grounds, Río Piedras, Aug. 1922.

Phyllachora Eriochloae Speg., Anal. Mus. Nac. Buenos Aires **19**: 416. 1909.

Seaver and Chardon (Sci. Surv. Porto Rico and Virgin Ids. **8**: 52) based mostly on determinations made by C. R. Orton, have reported the occurrence of this species in Porto Rico, on two hosts: *Paspalum conjugatum* Berg. and *Valota insularis* (L.) Chase. It seems evident, however, that we are dealing with two distinct forms, neither of which agree with the description of Spegazzini's species, which has spores described as "sporae oblique monostichae, apice altero obtuse rotundatae, altero abruptiuscule cuneatoacutatae, 14–15 × 7 u hyalino." None of the material from Port oRico or Santo Domingo properly falls under *P. Eriochloae* Speg.: the one on *Paspalum conjugatum* Berg. is referred here to *Phyllachora paspalicola* P. Henn, while the one on *Valota insularis* (L.) Chase is herein described as a new species, *Phyllachora insularis.*

Toro (Mycologia **19**: 80) also reports *Phyllachora Eriochloae* Speg. from Santo Domingo on the two above-mentioned hosts. After a careful examination of his material, the form on *Valota* insularis (L.) Chase, seems to be identical with the Porto Rican form *Phyllachora insularis* sp. nov., while the one on *Paspalum conjugatum* Berg., is a species of *Telimena,* described in this paper as *Telimena domingensis* sp. nov.

Thus it seems justifiable for the present to exclude *Phyllachora*

*Eriochloae* Speg. from both Porto Rico and Santo Domingo, thus restricting its range to continental South America.

**Phyllachora insularis** Chardon spec. nov.

Stromata mostly epiphyllous, but often hypophyllous, black, not shiny; at first small, punctiform, globose, 0.5 mm. in diameter arranged in linear rows parallel to the main axis of the leaf, later coalescing into large, conspicuous, irregular, black stromata 2–5 mm. long, 1–2 mm. wide, enclosing 3 to 5 or more locules; locules flat ellipsoidal, or angular, thru lateral pressure, 150–240 × 120–150 u, with a black, prominent clypeus on the roof of the locules, which may run along their sides and bottom; asci long-cylindrical, 60–75 × 6–8 u, 8-spored with the spores uniseriate in the ascus; spores hyaline, continuous, ellipsoidal with both ends obtuse, 8–10 × 4–5 u; paraphyses present.

This is evidently not *Phyllachora Eriochloae* Speg. whose spores are reported to measure 14–15 × 7 u. Our material does conform in macroscopic stromatal characters with Mayors No. *158* from Colombia which was first reported by Sydow (Mem. soc. neuch. Sci. nat. **5**: 436) as *Ph. Eriochloae* Speg., and later, by Theissen and Sydow (Ann. Mycol. **13**: 448) as *Ph. Eriochloae* Speg. var. *columbiensis*. The spores in the Colombian specimen, however, measure 10–12 × 4–5 u and the ends are acute, not blunt as in the Porto Rican and Santo Domingan material. These differences warrant the erection of a new species, distinct from the South American form.

On *Valota insularis* (L.) Chase.

Porto Rico: Barceloneta, Whetzel & Olive No. *551*, Feb. 25, 1916, (*type*); along river north of Peñuelas, Chardon No. *1021*, July 28, 1920; Finca Pretoria, Peñuelas, Chardon No. *1047*, July 20, 1920.

Santo Domingo: Santiago Kern & Toro No. *275*, Mar. 21, 1926; Bajabonico, Kern & Toro No. *252*, Mar. 23, 1926; Jaina, Kern & Toro No. *307*, Mar. 30, 1926.

Phyllachora Paspalicola P. Henn. Hedwigia **48**: 106. 1908.

Previously reported by Seaver and Chardon (Sci. Surv. Porto Rico and Virgin Ids. **8**: 52), as *Phyllachora Eriochloae* Speg. The spores of the Porto Rican material are distinctly lemon-shaped, 8–10 × 5–6 u, which evidently do not conform with the spore measurements of the Spegazzinian species.

It seems appropriate to refer it to *Ph. paspalicola* P. Henn: Although the type of this species (from Pará, Brazil) has not been seen, our material conforms very well with Mayor's No. *165*, from Colombia and determined as such by Sydow.

On *Paspalum conjugatum* Berg.

PORTO RICO: College grounds, Mayagüez, Chardon No. *918,* July 15, 1920; Corral Viejo, road to Adjuntas, Chardon No. *904*, Aug. 15, 1920.

**Phyllachora Paspali-virgati** Chardon spec. nov.

Stromata amphigenous, black, not shiny, 1–2 mm. long, 0.5 to 1 mm. wide, with 2 to 3 locules, entirely immersed in the mesophyll of the leaf, bordered on all sides with black stromatal tissue; locules flat globose or angular thru lateral pressure, 125–200 × 100–125 u; asci cylindrical, 8–spored; spores uniseriate in the ascus, hyaline, continuous, long–elliptical with both ends obtuse, 8–10 × 4–5 u; paraphyses present.

The spores in this species agree in shape and size with those already given for *Phyllachora insularis* sp. nov. but in stromatal characters, the two forms are quite distinct: In *Ph. insularis* the stromata are mostly epiphyllous with scarcely any stromatal tissue under the locule, while in *Ph. Paspali-virgati* the stromata are amphigenous and the locules surrounded on all sides by the black stroma.

On *Paspalum virgatum* L.

PORTO RICO: Along railroad, San Germán, Whetzel and Olive, No. *559* (*type*), Apr. 2, 1916; Poultry Farm, Guaynabo, Whetzel, Kern and Toro, No. *2570,* June 25, 1924.

**Phyllachora macorisensis** Chardon spec. nov.

Stromata amphigenous, black, not shiny, scattered 0.5 to 1.5 mm. long × 0.3–0.5 mm. wide; fructification simple, more often compound, with 2–3 or rarely 5 loculi; locules elliptical, flattened, or irregular thru lateral pressure, 160–200 × 120–140 u; asci cylindrical-clavate, 75–90 × 8–12 u, 8–spored; spores ellipsoidal, hyaline or faintly pale, 1–celled, 10–11 × 4–5.6 u, uniseriate; paraphyses filiform, longer than the asci.

No *Phyllachora* has been reported to occur on *Stenotaphrum.* This seems to be quite distinct from other known species on Gramineae.

On *Stenotaphrum* sp.

SANTO DOMINGO: San Pedro de Macorís, Kern & Toro, No. *150,* Mar. 10, 1926 (*type*).

**Phyllachora Rhynchosporae** Chardon spec. nov.

Stromata amphigenous black, not shiny, scattered, 0.5 to 1.5 mm. long × 0.2 × 0.5 mm. wide; fructification simple, or rarely compound, with 2 or at the most 3 loculi; locules elliptical globose, somewhat flattened, seldom irregular, 120–200 × 100–135 u; asci

elliptical-clavate, somewhat bulged in the middle, 85–110 × 16–22 u, 8–spored; spores navicular with the ends acute, faintly pale, uniseriate above and below, biseriate in the main body of the ascus, 1–celled, 15–17.5 × 4–4.5 u; paraphyses filiform, longer than the asci.

No *Phyllachora* has been reported on *Rhynchospora*, although several are known to occur on other cyperaceous hosts. The spore characters of this species are very distinct, and entirely justify the erection of a new species.

On *Rhynchospora cyperoides* (Sw.) Mart.

SANTO DOMINGO: Santo Domingo City, Kern & Toro No. *302*, Mar. 27, 1926 (*type*).

**Sphaerodothis antioquensis** Chardon spec. nov.

Stromata amphigenous, black, shiny, equally visible on both surfaces of the leaf, 1.0–1.5 mm. long to .8–1.0 mm. wide, the longer dimension following the main axis of the leaf, very seldom coalescing; fructification simple, with stromata immersed in the mesophyll of the leaf and the locule entirely covered by black stromata, locule flattened, large, 250–350 × 75–120; asci clavate, 8–spored, 65–78 × 20–23, with the spores inordinate in the ascus; spores elliptical, with blunt ends, 1–celled, distinctly brown in color 16–20 × 10–12 u; paraphyses present.

There being no species of *Sphaerodothis* reported on this host, the fungus is described herein as a new species.

On *Arthrostylidium* sp.

COLOMBIA: R. A. Toro, No. *284*, Santiago, Dept. of Antioquia, No. 13, 1927 (*type*).

**Sphaerodothis luquillensis** Chardon spec. nov.

Spots not exceeding the stromata; stromata amphigenous, black, shiny, small at first, 0.8–1 mm. long × 0.4–0.7 mm. wide, with the long axis parallel to the main axis of the leaf, later coalescing profusely, forming rows of linear stromata several millimeters long, unilocular in a cross section of the leaf; locule 250–300 × 120–150 u; asci cylindrical-clavate, 8–spored, 84–95 × 7–8 u, with the spores arranged uniseriately; spores at first broad elliptical, hyaline, 1–celled full of oil droplets, 12–14 × 6–6.5 u, later turning light brownish and reducing in size, at full maturity, long elliptical, with acute ends, distinctly brown in color, evanescent, 1–celled, 8–9 × 3–3.5 u; paraphyses profuse.

No species of *Sphaerodothis* appears to occur on Gramineae in Theissen and Sydow. The spore characters of this form are quite

distinct. The reduction in the size of the spores as they aproach maturity is interesting and has been clearly followed by the writer.

On *Eriochloa punctata* (L.) Desv.

PORTO RICO: C. E. Chardon & M. F. Barrus No. *3113*, La Catalina coffee farm, Luquillo Mountains, Jan. 21, 1928 (*type*).

**Telimena domingensis** Chardon spec. nov.

Stromata on both surfaces of the leaf, small, black, not shiny, less than 1 mm. in diameter, mostly uniloculate, seldom biloculate; locules 150–190 × 100–125 u, entirely immersed in the mesophyll and surrounded by a black stroma, at first enclosing numerous 1–septate, fusoid, hyaline stylospores, 21–24 × 2–3 u; asci cylindrical-clavate, 48–56 × 4–5 u, 8–spored with the spores arranged biseriately in the ascus; spores fusoid, 3–septate, hyaline to greenish with both ends acute, 12–14 × 2–3 u; paraphyses present.

Thru an error in determination this was reported by Toro (Mycologia **19**: 80) as *Phyllachora Eriochloae* Speg. *Telimena graminella* Sydow (Fungi, exot. exc. *399*) on *Paspalum* from the Philippines, has much larger spores, 20–25 × 4–4.5 u.

On *Paspalum conjugatum* Berg.

SANTO DOMINGO: San Cristobal, Kern and Toro, No. *156*, Mar. 12, 1926 (*type*).

**Ophiodothella floridana** Chardon spec. nov.

Spots large, very conspicuous, roughly circular or irregular through coalescence, 8–15 mm. across, amphigenous but more pronounced in the undersurface of the leaf, with a black, not shiny, conspicuous stroma, 5–12 mm. across, in the center of the spot, bordered by a distinct yellowish zone which borders the stroma on all sides; stroma multiloculate, with locules in a row facing the undersurface, immersed in the mesophyll of the leaf, with heavy stroma above, lighter below; locules globose or elliptical, 250–350 × 200–280 u; asci cylindrical-clavate, 8–spored, 80–112 × 11–13 u; spores filiform, 1–celled, hyaline, 56–64 × 4 u; paraphyses present. (Plate II, Fig. 5).

A conspicuously large form, superficially resembling some species of *Catacauma* known on various *Ficus*, but falling in the genus *Ophidothella* v. Hohn, on account of its filiform spores.

On *Ficus* sp.

FLORIDA: U. S. Dept. Agric. No. *60925* (collected by L. H. Mc Cullough) Miami, no date (*type*).

Río PIEDRAS, PORTO RICO.

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## EXPLANATION OF PLATES I AND II.

Fig. 1. Small branch of *Eugenia* sp. showing tar-spot stromata of *Catacauma semilunata* sp. nov. (nat. size).

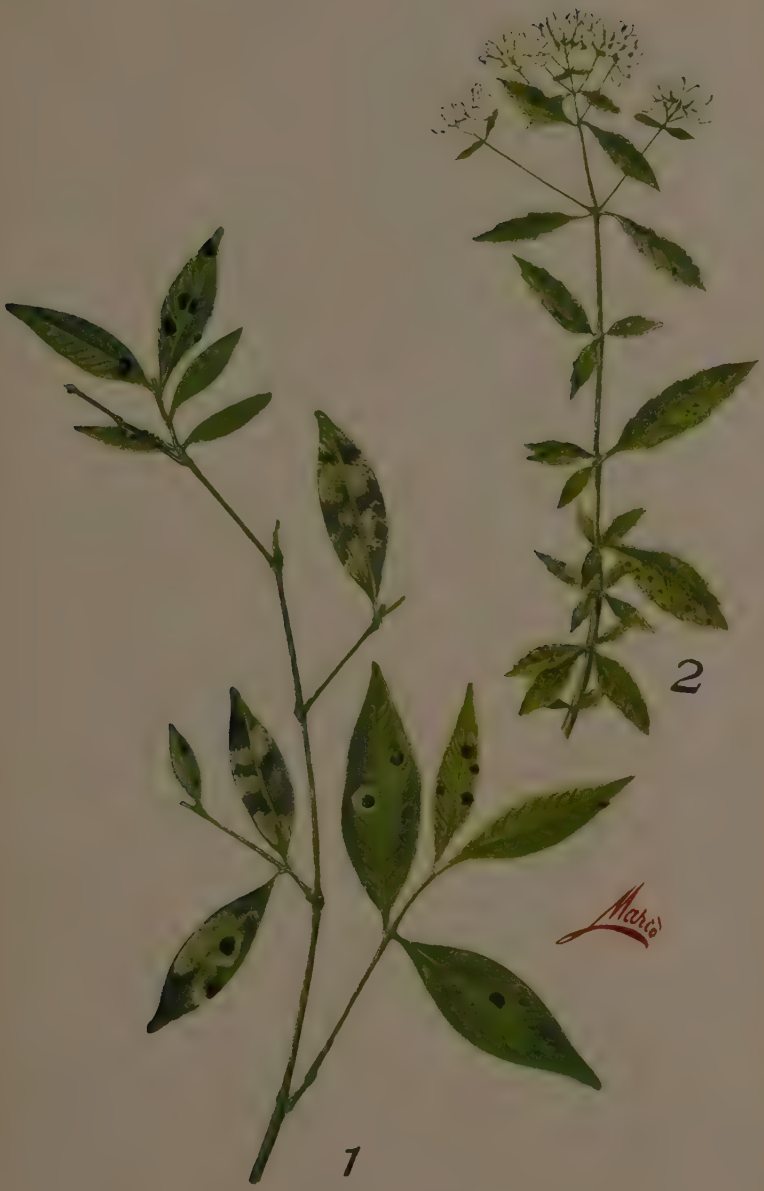
Fig. 2. Small branch and inflorescence of *Eupatorium tacotanum* showing small inconspicuous stromata of *Robledia tetraspora* gen. et sp. nov. (nat. size).

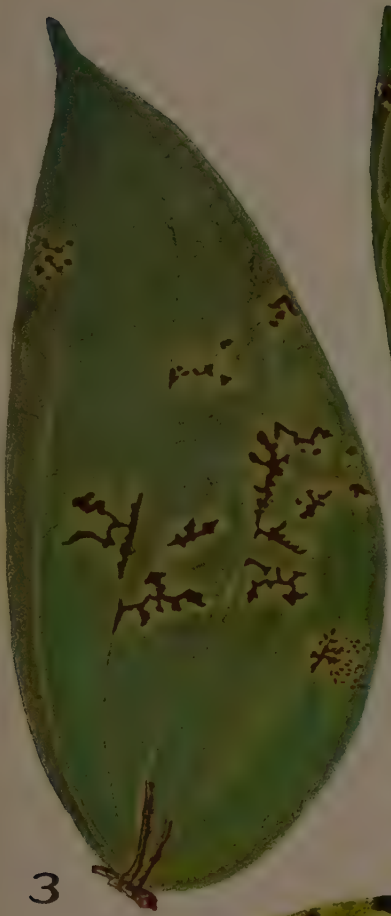
Fig. 3. Leaf of *Bauhinia* sp. showing laberynthiform stromata of *Catacauma Weirii* sp. nov. (nat. size).

Fig. 4. Leaf of *Ficus* sp. showing conspicuous stromata of *Ophiodothella floridana* sp. nov. (nat. size).

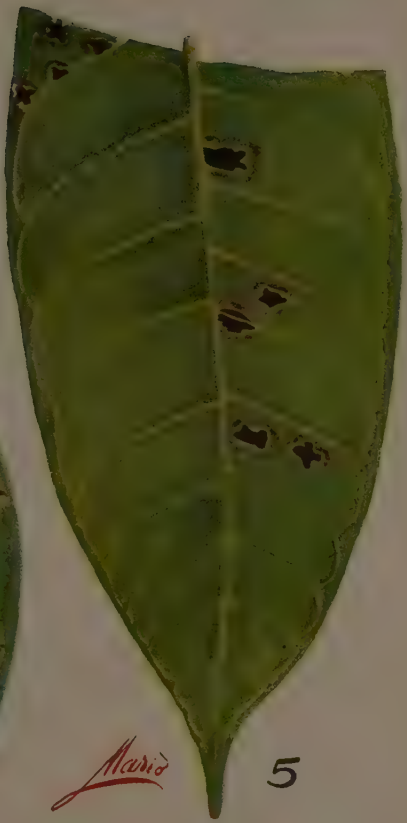
Fig. 5. Leaf of *Mangifera indica* showing tar-spot stromata of *Trabutia Mangiferae* sp. nov. (nat. size).

PLATE I.





3



5

4

# LIFE HISTORY OF LIGNIERA VASCULARUM (Matz) Cook

(Formerly known as *Plasmodiophora vascularum*).

MELVILLE T. COOK

(WITH PLATES III–VI)

This organism is the cause of a disease of sugar cane in Porto Rico and was described by Matz (**12**) in 1920 under the name of *Plasmodiophora vascularum*. The organism has not been reported from any other part of the world. This paper is a record of studies on the life history of the organism which have resulted in the author transferring it from the genus *Plasmodiophora* to the genus *Ligniera* Maire and Tison.

## HISTORY

The organism was first reported by Matz (**12**) in 1920 as the cause of a disease of sugar cane commonly known as "dry top rot". He reports his first discovery on Cavengerie cane at Bayamón in the fall of 1919. In this and a later paper (**13**) he reports the disease on a Porto Rico seedling, Otaheite, Crystalina, Rayada, D–109 and Yellow Caledonia. In the second paper he states—"The disease was found distributed in practically all the principal sugar-cane-growing sections of the Island, on the north coast as well on the irrigated south coast, in isolated areas on the western end, and in the central district around Cayey and Morovis. It was particularly noticeable in fields which showed evident signs of retarded growth and dwarfing especially in ratoon fields".

In his second paper (**13**) Matz states that "From observations made on sugar cane diseases in Porto Rico it is now certain that in so far as reduction of yield is concerned this dry top rot or vascular disease is the most serious of the three or four major diseases of sugar cane existing at present in Porto Rico".

The writer of this paper has found the disease well distributed over the Island and on several varieties but has found but one severe outbreak which was in the vicinity of Canóvanas and involved about 300 acres of D–109 which was growing on low wet land. The other outbreaks observed by the writer were in some cases severe but over small areas and always in wet land. Numerous small out-

breaks were observed, usually in the coastal plains. Several infected stools were found in a small poorly drained field near Cayey which is about 1,300 feet above sea level. The controlling factors appear to be susceptibility of varieties and amount of moisture.

## SYMPTOMS

The disease gets its name "dry top rot" from the dying and drying of the tops but it should be remembered that a dying of the tops may be due to borers and to other causes. This symptom is proceeded by a reduction of the leaves and frequently by a rolling and wilting of the leaves. In severe cases a part or all of the canes in a stool may be dwarfed and die from the tops down. These dead tops are frequently attacked by saprophytes which cause a decay. It is not unusual to find many canes of various ages, especially those under five feet in height, dead from this disease. These dead canes may lose all their leaves and are frequently attacked by the rind fungus (*Melanconium sacchari*) which may mislead the observer as to the true cause of the dying. When infected canes are cut across at the base, some of the fibro-vascular bundles show a lemon or orange yellow color. When the sections of this tissue are examined under the microscope the tracheary tubes of these bundles will be found to be filled with a plasmodium or large spores. It is very evident that this plugging of these water passages will be disastrous to the growth of the cane. However, weak or dead canes may show only a few infected bundles and it is difficult to understand just how such slight infection can kill the canes. The organism can also be found in the roots. After a time the organism may disappear and the bundles show a pronounced red color. Although some of these external symptoms may be common to other diseases of the sugar cane, the presence of the spores in the tracheary tissues is so characteristic that the disease cannot be confused with any other known disease of sugar cane.

Matz described (**12**) the organism as follows: "The spores in their advanced stage in the interior of the vessels of fibro-vascular bundles are spherical with smooth, somewhat thick hyaline walls, evenly granulated or sometimes coarsely granulated in the interior, orange, yellow, sometimes slightly brown in color, measuring .014–.016 millimeters in diameter. Spores are embedded in a yellowish hyaline, at length hard matrix. Plasma is composed of a mass of granular cytoplasm, later developing into individuals composed of clear cytoplasmic variable bodies having a dense, darker, granular center".

The writer of this paper was induced to take up the study of

this disease and the organism causing it, (1) because it appeared that the disease was likely to prove of major importance and (2) because it appeared to be desirable to make more extensive comparisons of the organism with other genera and species of the Family-Plasmodiophoraceae.

## METHODS

The methods of work were as follows: (1) Field observations were made to determine symptoms, severity and resistant varieties. (2) Free hand sections of fresh material were made and studied in the laboratory. Sections were mounted in sterilized water and kept under observation for the purpose of observing germination of spores. Blocks of fresh material were kept in sterilized water for the same purpose. (3) Material was killed and fixed by several methods, embedded in paraffin, sectioned and stained by several methods. Flemming's weaker fluid and Haidenhain's iron-alum haematoxylin stain were most satisfactory.

## LIFE HISTORY

The life history resembles that of a number of other species of the family *Plasmodiophoraceae*. The plasmodium is produced in abundance and frequently fills the tracheary tubes (Fig. 1). It is very evident that this is the product of germinating spores; and spores that have failed to germinate are frequently found in this plasmodial mass (Fig. 1). The plasmodium may be uniform in character (Fig. 1) or it may vary in density (Fig. 2). Matz states that it occurs in the annular and spiral tracheids and pitted vessels in the fibro-vascular bundles in the lower nodes. In some cases the writer of this paper found the organism in the tracheary tubes only, while in other cases it was also found in the surrounding cells of the fibro-vascular bundle and rarely in the parenchyma cells (Figs. 3 and 9). Both the plasmodium and the spores were most abundant in the basal part of the plant but were sometimes found at a considerable distance above ground. The older or more mature stages are always below the younger stages, indicating that the organism was moving upward into the growing plant. The stages of development in these adjoining cells are not always the same; some may shown plasmodia while others show spores in various stages of development (Figs. 3 and 9). Nuclei could not be seen in any of the preparations until the spores began to form (Figs. 4 and 5) and sometimes the nuclei were not visible even when spore formation was well advanced (Figs. 3 and 6). In some few cases the nuclei were very prominent at an

early stage of spore development (Fig. 8). The first stages in spore formation were very indistinct (Figs. 4 and 5), but later became more definite (Fig. 6). In some cases the entire mass of plasmodium appeared to have been consumed in spore formation (Figs. 6 and 7), while in other cases only a part had been used (Figs. 3, 8 and 9), the remainder forming a matrix in which the spores were embedded.

The cell wall appears as a single membrane early in the spore formation (Figs. 8, 9, 10, 11 and 12), but thickens with age (Fig. 18). In the early stage of spore development a spore appears as a uniform granular mass, surrounded by a delicate membrane and with a single nucleus which stains deep and uniform (Figs. 9, 10, 11 and 12). In some few cases these developing spores show bodies which turn black under the action of Flemming's fluid (Fig. 13) and resemble nuclei. They are probably fat bodies. These spores vary greatly in size (Figs. 14, 15, 16 and 17), but the writer was unable to determine just how much growth was made after the formation of the cell wall. In its further development numerous vacuoles are formed in the protoplasm, the nucleus becomes large with a well defined nucleolus and the cell wall becomes very thick (Figs. 15, 16, 17 and 18). The cell wall is so thick that the killing fluids do not penetrate readily. Therefore, it is difficult to study the contents of the mature spores but the protoplasm may be dense or vacuolar and fat bodies may be few or abundant. The spores are smooth and when not subject to pressure are spherical in form (Fig. 18). When mature these spores usually fill the large tracheary tubes (Fig. 19), but in some cases excess plasmodium is visible. In small tubes the spores may lie in a single row (Fig. 16), while in large tubes they form a mass (Fig. 19). When mature the spores in any individual tracheary tube are usually quite uniform and of a maximum size, but some variations may occur (Fig. 19). They are usually lemon or orange yellow or slightly brownish in color when old.

The germination of these spores and their behavior after germination is rather difficult to follow. Matz (**12**) says: "At first an attempt was made to germinate the spores of the organism in water, in sugar water, in cane juice, in fermented but sterilized cane juice and in several agars but no germination was observed to have taken place. Spores were kept in moist cells for over six months and no germination was observed to have taken place. Portions of cane stalks which contained bundles filled with the organism in its several stages were cut and placed in moist chambers together with healthy seed pieces of Rayada cane, and after five months it was found that the roots of the Rayada cane contained many of the

spherical spores of the organism. Apparently a transfer of the organism from its original seat into the healthy cane had taken place. Inoculations with bits of infested bundles into six healthy canes were made in the basal regions of the latter. The six cane stools thus inoculated showed marked stunting in contrast with other uninoculated canes growing alongside of the former''.

The writer of this paper found this phase of the problem quite difficult and is not sure that all the observations are absolutely correct. When apparently mature spores were squeezed out into drops of sterilized water on clean slides and kept in moist chambers, short germ tubes were produced on a large percentage of them (Fig. 20). In many cases the points of these tubes were open and the contents gone but the writer never succeeded in seeing one of them open and the contents emerge. A few spores with germ tubes were found in the tracheary tubes. Free swimming zoospores were observed and, although it was difficult to make sure that sterilization processes for the destruction of other organisms were all that was to be desired, it is reasonable to suppose that they came from the spores. The movement of these zoospores was very rapid and it was difficult to make a satisfactory study, but they appeared to be uni-ciliate. This opinion appears to have been confirmed by the findings of two uniciliate zoospores (Fig. 21) in the tracheary tubes in prepared sections. Neither union nor division of these free swimming zoospores were observed but numerous cells of various sizes, that appeared to have possessed euglenoid and amoeboid characters were observed in the tracheary tubes in the prepared sections (Figs. 22 and 23). Therefore, it is reasonable to assume that the flagellate zoospores become euglenoid, then amoeboid and that they eventually unite to form the plasmodium, thus completing the life cycle. Actively growing cane would undoubtedly furnish abundant food for a rapid growth of the organism. However, other stages, such as unions and divisions may have occurred and not been observed by the author.

Judging from the preceeding studies it appears probable that spores may germinate in the tracheary tube and unite to form a plasmodium and that the organism travels from the older to the newer parts of the plant either as zoospores or as a plasmodium and may complete the life history without escaping from the host. Since the new shoots of a diseased stool are very generally infected, it is also reasonable to assume that the zoospores or the plasmodium may travel downward and then out into the new shoots in the same manner that they may travel upward into a growing shoot.

### Effect on Tissues of the Host

There was no cell destruction or hypertrophy of the host tissues as in the case of other species of the genus *Plasmodiophora* and this is the character on which Maire and Tison (**10, 11**) erected the genus *Ligniera*. The hypertrophies of the tissues of the hosts which are induced by some species of *Plasmodiophora* may be explained by the fact that these parasites attack active meristomatic tissues, while this organism attacks the tracheary tissues which have passed the meristomatic stage. Vascular tissues occur in potato warts (*Chrysophlyctis endobiotica* Schild) (**1, 7, 15**) but the warts are apparently the result of a stimulation of meristomatic tissues of the host which have resulted in the formation of both parenchyma and vascular cells. None of the papers which have come to the authors attention indicate any stimulation of vascular tissues. This interpretation is in harmony with studies by the author on plant galls caused by insects and other abnormal plant growths. The infested fibro-vascular bundles eventually become red, but this reddening which is quite common in the lower parts of canes is not necessarily an indication of disease.

### TRANSMISSION

The method of transmission of this organism from plant to plant and from place to place has not been thoroughly studied. It appears that the organism can complete its entire life cycle repeatedly in the fibro-vascular bundles of the growing cane, gradually working from the base upward, so long as it does not kill the individual cane in which it is living. It is also evident that slightly infected canes will have a better chance of surviving than severely infected canes. Slightly infected canes which do not show the symptoms of the disease are very likely to be used for seed and become carriers of the organism. There is abundant evidence to show that this is the case. In the 300 acres of severely infected D–109 to which the writer has referred (page 19) the source of the disease was traced with a reasonable degree of certainty to a field growing on a higher elevation, from which the seed cuttings were obtained and in which the symptoms were few and insignificant, but in which slightly infected canes were found without difficulty. The difference in severity of the disease in the parent and daughter fields was no doubt due to the fact that the differences in elevation and drainage in the two fields made the conditions for the growth of the organism more favorable in the daughter than in the parent field.

The formation of free swimming zoospores and the fact that the disease is most severe in wet soils are reasons for believing that the organism can travel from plant to plant. The experimental work on this phase of the problem is insufficient to justify any definite statements at this time (see page 23). However, it is well known that the zoospores of *Plasmodiophora brassicae* (**4**) and some species of *Ligniera* (**10, 11, 16, 17, 18**) gain entrance to healthy plants through the roots. There is some difference of opinion as to whether this entrance is directly into the root or first into the root hairs and thence into the roots, but the evidence indicates that it is through the root hairs. This organism is known to exist in the roots of the sugar cane but its method of entrance has not been studied. Chupp's (**4**) studies on *P. brassicae* indicate that the zoospores do not travel far in the soil. However, organisms of this kind may be carried on farm implements or in drainage or irrigation water for a considerable distance. This phase of the problem should be studied.

### COMPARISON WITH RLATED ORGANISMS

The organism was originally placed by Matz in the genus *Plasmodiophora* but it differs from other species of this genus in that it does not produce hypertrophy of the host tissues. According to the present classification it belongs in the genus *Ligniera* which was formed by Maire and Tison (**10, 11**) to include those species of *Plasmodiophoraceae* which produce little or no hypertrophy of the host tissues. It is interesting to note that this classification is based primarily on the reaction of the host to the parasite and not on morphological characters or life history of the parasite. However, this classification has been recognized by some of the leading students of this order, who are referred to in this paper. Therefore, it is desirable to compare this organism with recogized species in these and other genera of the *Plasmodiophoraceae,* especially belonging to the genera *Plasmodiophora* and *Ligniera.*

One very marked difference between *Plasmodiophora brassicae* and *Ligniera* (*Plasmodiophora*) *vascularum* is that the former attacks the parenchyma tissues while the latter lives primarily in the tracheary tissues. The plasmodium of *P. brassicae* produces resting spores which germinate in a very similar manner to what we find in *L. vascularum.* Chupp (**4**) was able to observe the germination of the spores of *P. brassicae* and states that the actual germination is proceeded by a swelling of the resting spore which is not true in the case of *L. vascularum.* The zoospore of *P. brassicae* was uniflagellate and pyriform as in *L. vascularum.* However, he did not observe

the various amoeboid forms recorded by Woronin (**20**) and which the writer believes to be characteristic of *L. vascularum*. Both Lutman (**9**) and Chupp (**4**) have demonstrated that the zoospores of *P. brassicae* enter new plants through the root hairs and Chupp figures an amoeba in a swollen root hair. This has not been worked out for *L. vascularum*. Chupp's experiments indicate that the zoospores of *P. brassicae* travel very short distances in undisturbed soils.

In 1911 Maire and Tison (**10, 11**) erected the new genus *Ligniera* for two new species, *L. verrucosa* and *L. radicalis*, which they described. To this new genus they transferred *Sorosphaera Junci* Schwartz (**16**). In 1912 Winge (**19**) reviewed the order *Plasmodiophorales* and placed in the genus *Ligniera* four of his own species which he had previously placed in the genus *Sorosphaera*. In 1914 Schwartz (**17**) recognized the validity of the genus *Ligniera* and described three new species. In 1925 Fron and Gaillat (**6**) described *Ligniera pilorus* on *Poa annua* which they separated from the closely related *Ligniera radicalis* because it produced an enlargement of the root hairs. Schwartz was unable to germinate the spores but Maire and Tison found zoospore formation in *Ligniera radicalis*. Fron and Gaillat also found zoospores. It is very generally believed that the zoospores of the species of this genus gain entrance to the host through the root hairs but the evidence is by no means complete. Cook (**2**) says "When the amoeba is lying in a root hair a swelling is sometimes noticed, though infected root hairs showing no hypertrophy are more common". In 1925 Fron and Gaillat (**6**) separated *Ligniera pilorum* from *Ligniera radicalis* because it induces hypertrophy in the root hairs of the host. However, there is no record of species of the genus *Ligniera* causing hypertrophy in the roots.

The preceding studies indicate that this organism should be transferred to the genus *Ligniera*. The writer therefore proposes the following transfer and revised description:

**Ligniera vascularum.** (Matz) comb. nov.

*Plasmodiophora vascularum* Matz, Jour. Dept. Agr. P. R. **4**: 45. 1920.

A yellowish, granular, plasmodium, resting spores or zoospores inhabiting the tracheary tubes and occasionally surrounding cells of sugar cane. The resting spores usually granular, orange, yellowish or slightly brownish in color with thick hyaline walls and measuring about .014–.016 millimeters in diameter. Zoospores pyriform and uniflagelate, becoming euglenoid and amoeboid.

## CONTROL

At this time the disease appears to be of minor importance but its presence on the Island is a menace to susceptible varieties especially when grown on wet lands and it may at any time become an important disease on new or introduced varieties. Therefore it is inadvisable to use seed from fields in which the disease is known to occur. Slightly infected seed cuttings may become carriers of the organism from field to field or to distant localities.

## SUMMARY

1. The organism previously known as *Plasmodiophora vascularum* Matz is transferred to the genus *Ligniera* Maire and Tison.

2. This organism lives primary in the tracheary tissues of the sugar cane but accasionally spreads to surrounding tissues. It does not cause hypertrophy of the host tissues.

3. It is the cause of a disease of sugar cane known locally as "dry top rot".

4. It is known only in Porto Rico and only in cane.

5. The life history is very similar to that of *Plasmodiophora brassicae* Wor. and to several species which have been placed in the genus *Ligniera* by Maire and Tison, Fron and Gaillat, Guyot, Schwartz and Winge.

The writer wishes to express his thanks to Commissioner Carlos E. Chardon, Director F. Fernández García, Mr. A. R. Cochran of Central Canóvanas and others for assistance in making these studies. Thanks are also due to Dr. R. Ciferri of the Estación Nacional Agronómica, Moca, S. D., for suggestions and bibliographic assistance. Also to Dr. J. H. Barnhart of the New York Botanical Garden for assistance in examining the literature.

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## Figures

### PLATE III

**Fig. 1.**—Plasmodium in tracheary tube. Also one resting spore which did not germinate.

Fig. 2.—Cross section of tracheary tube showing plasmodium.

Fig. 3.—Cross section of part of fibro-vascular bundle showing plasmodium in tracheary tube and some surrounding cells. Also early stage of spore formation.

Figs. 4 and 5.—Plasmodium showing early stage of spore formation. Note the nuclei.

### PLATE IV

**Fig. 6.—Early stage of spore formation and one resting spore of preceding generation which has not germinated.**

Fig. 7.—Tracheary tube showing slightly advanced stage in spore formation. Note the nuclei.

Fig. 8.—Early stage in spore formation. Note the nuclei and delicate cell wall.

Fig. 9.—Cross section of part of fibro-vascular bundle, showing spore formation in tracheary tube and plasmodium in surrounding cells.

PLATE V

Fig. 10.—Early Stage in spore formation and one resting spore from same tube which has not germinated.

Fig. 11.—Group of forming spores.

Fig. 12.—Group of forming spores in tracheary tube.

Fig. 13.—Young spores showing black spots which are nuclei and fat bodies.

Fig. 14.—Forming spores of various sizes.

Fig. 15.—Spores in advanced stages showing nuclei and vacuoles.

Fig. 16.—Part of small tracheary tube with single row of spores. Slightly shrunken.

Fig. 17.—Oblique section of tracheary tube showing immature spores of several sizes.

PLATE VI

Fig. 18.—Two mature spores.

Fig. 19.—Diagramatic drawing of spores in a tracheary tube.

Fig. 20.—Two spores with germ tubes.

Fig. 21.—Flagellate cells.

Fig. 22.—Euglenoid cells.

Fig. 23.—Amoeboid cells.

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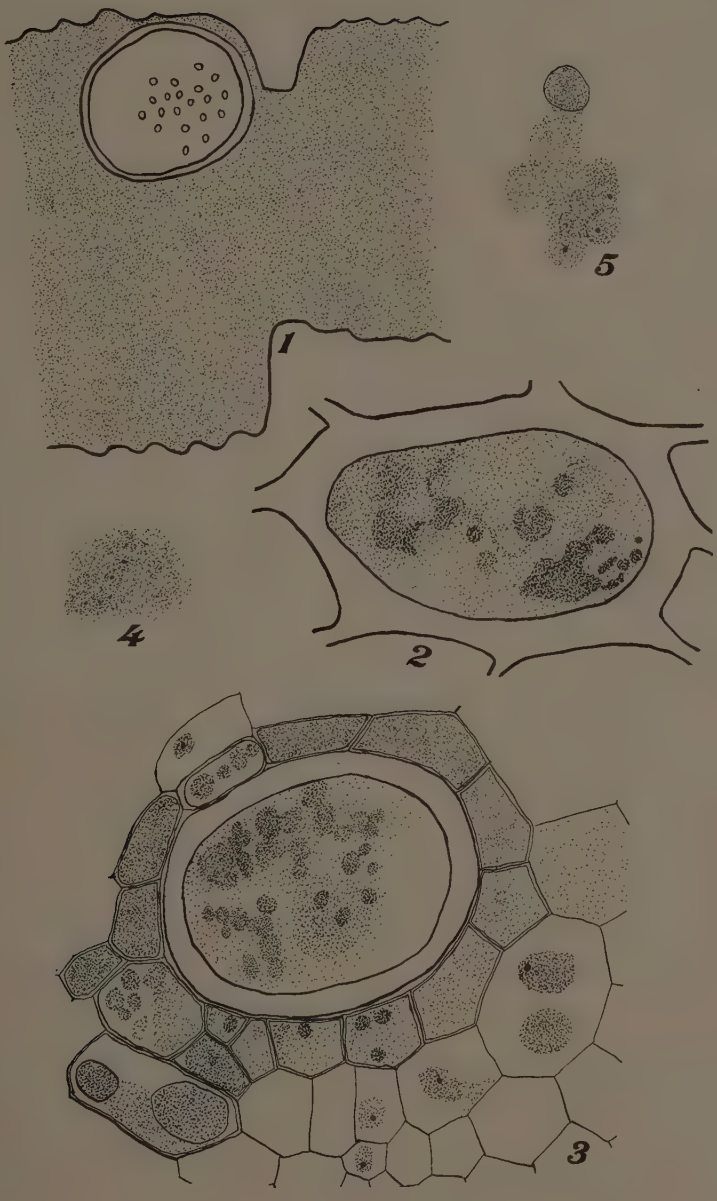
PLATE III.



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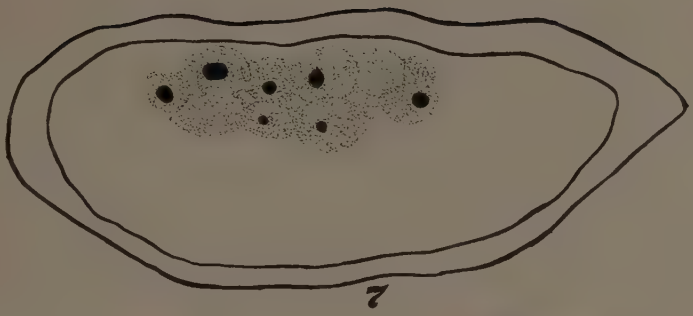

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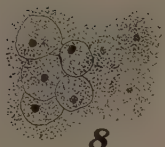

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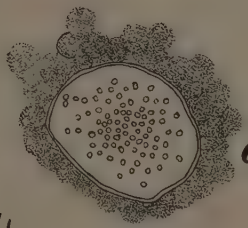

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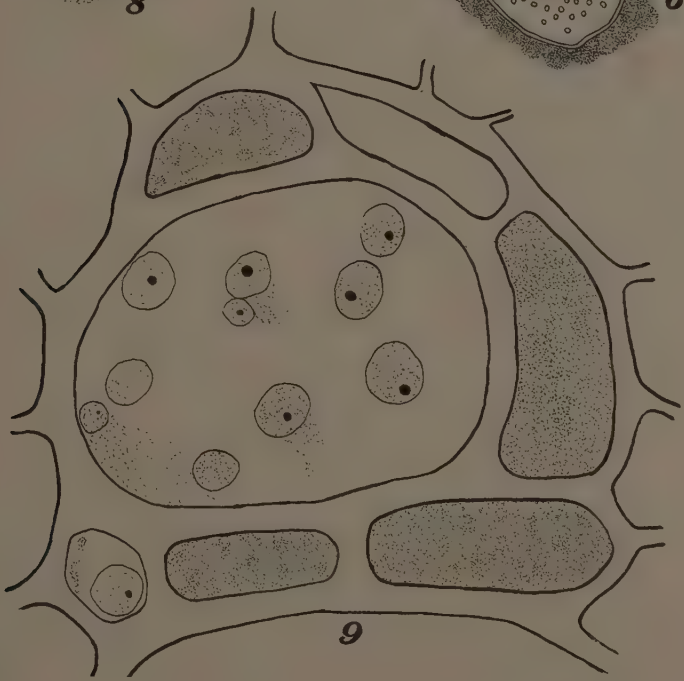

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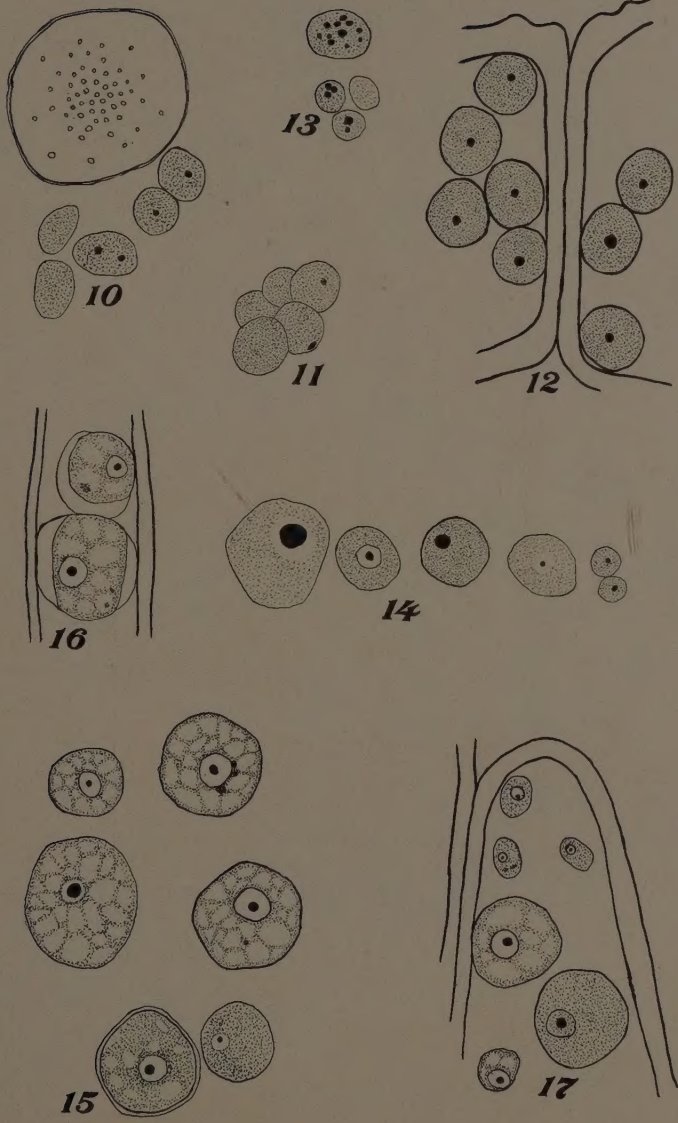
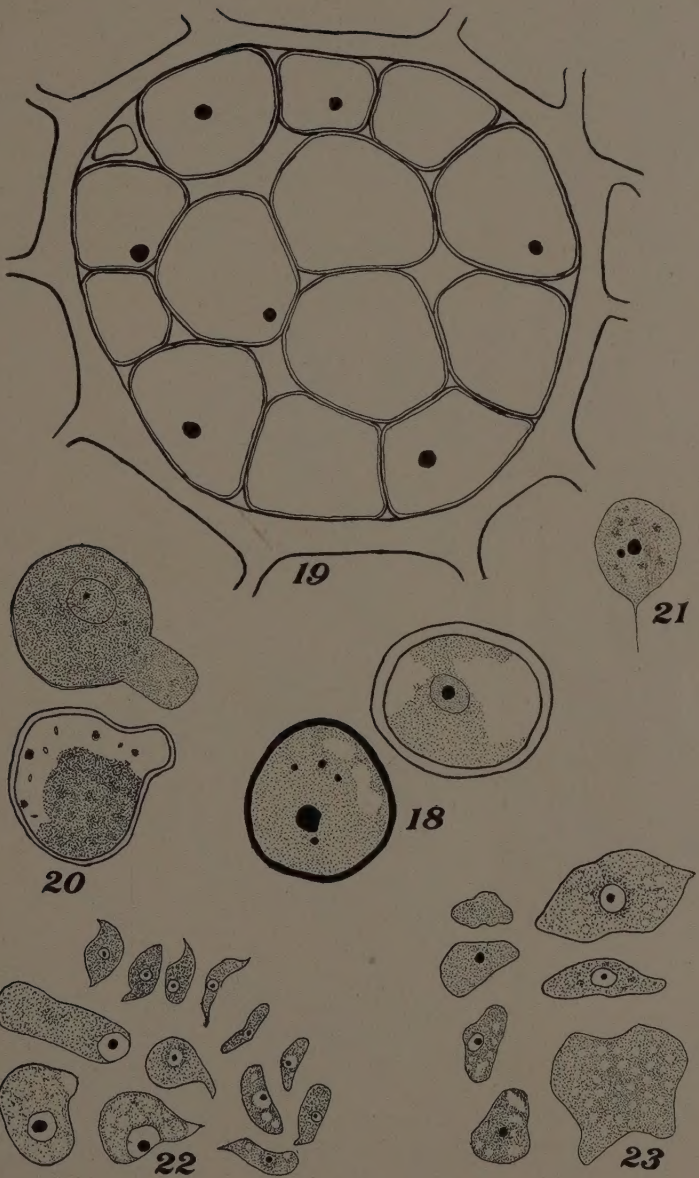
PLATE V.

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